The Federal Democratic Republic of Ethiopia Regional State of Tigray Bureau of Water Resource

Msrar Teli Diversion Irrigation Project
Head Work and Infrastructure
Final Detail Design Report

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Salient features of the Misrar Teli diversion headwork and infrastructure

Administration location

- Zone south eastern
- Woreda Enderta
- Tabia Mahbere genet
- Kushet Tslwe
- GPS location(Adindan) Easting-0545455.03

  Northing-1500099.6

  Elevation-1860

Headwork

- Peak discharge 220m3/s
- Return period 50
- Crest length 29
- Type of weir broad crest
- Weir height 0.6m

Main canal

- Duty used for design of canal capacity 1.9 litters/second
- Length 2.750km
- Type of canal lined rectangular
- Gully crossing five gully crossing
- No division box three division box
- Bed width 0.4m
- Depth 0.4m
- Freeboard 0.2m

Secondary canal

- Length 1465.9km
- Type of canal lined rectangular
- No of drops 13
- Command area 52.5 hectares

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LIST OF ABBREVIATIONS AND SYMBOLS

DB1	division box 1
DB2	division box-2
DB3	division box-3
IFAD	International Fund for Agricultural Development
MC	main canal
SC-1	secondary canal-1
SC-2	secondary canal-2
SC-3	secondary canal-3
TWRB	Tigray water Resource Bureau
TWWSDSE	Tigray Water Works Study Design and Supervision Enterprise

1. INTRODUCTION

1.1. Background the study area

To make a better life for farmers a coordinated and a strategic plan of irrigation practice is required. As a nation we have poor reputation on irrigation. This is true for most regions including Tigray. History tells us how devastating it is to depend on rain based agriculture practice. Now day's irrigation developments are getting more attention from government and development supportive institutions like IFAD.

1.2. Description of the study area

1.2.1. Location

Msrar teli irrigation project area is found in Tigray Regional State in Enderta woreda at tabia Mahbere genet. Geographically the proposed area is located in the coordinate of 545455.03E latitude and 1500099.6 N longitudes; its altitude is 1860 m.a.s.l

Table 1-1: list of benchmarks used

Easting(m	Northing(m)	Elevation(m)	Remark
545104.142	1500428.298	1863.213	**GPS 2**
545037.777	1500331.982	1880.122	**GPS 2A**
544310.66	1501134.232	1840.643	**GPS 1**
544362.851	1501108.374	1857.43	**GPS 1A**
544763.88	1500670.217	1883.535	**BM*1**

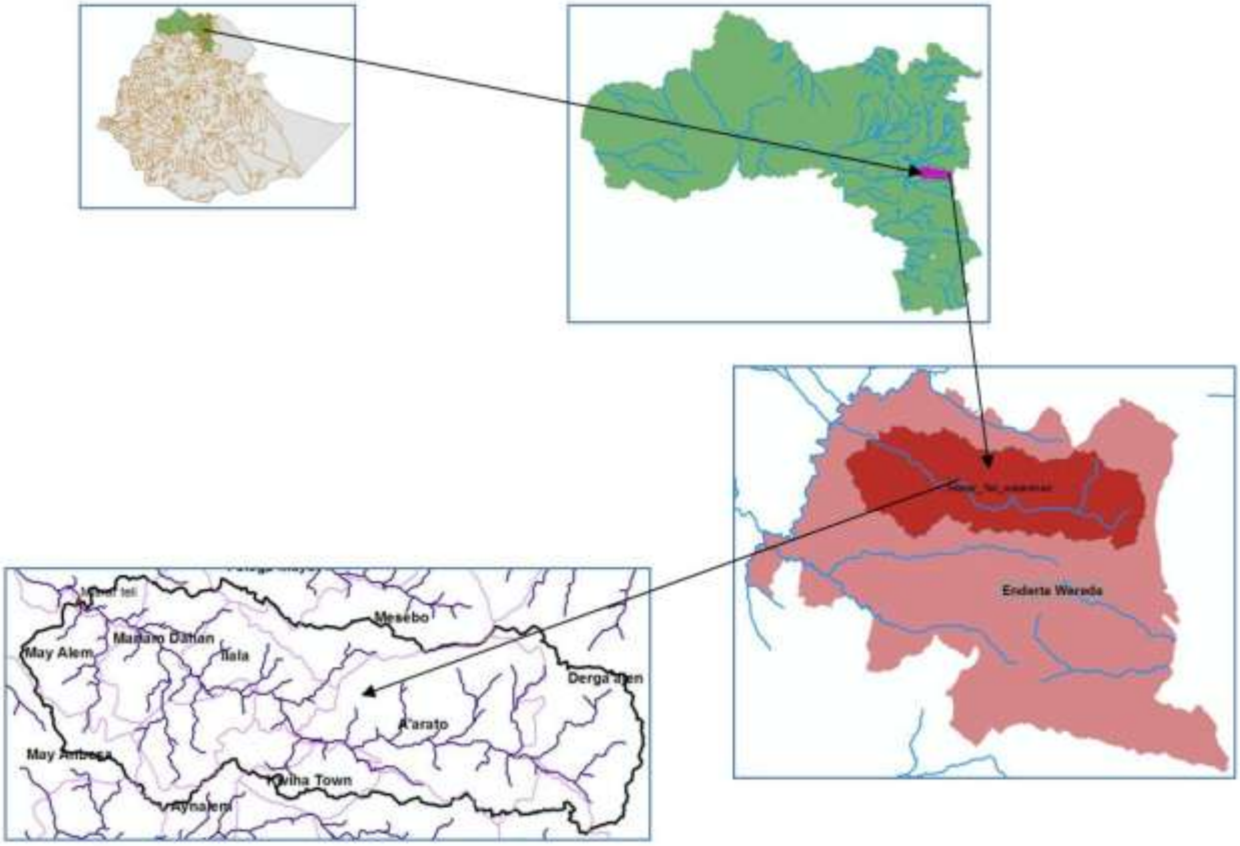


Figure 1: Location Map of the Study Area

1.2.2. Topography

Altitude of the study area ranges from 1800 meters to 1860 meters above mean sea level. The topography of the project area is steep in the upper catchment with defined drainage lines.

1.2.3. Road accessibility

The site is accessible by 10km mekelle-Hagereselam asphalt road and additional 2 km dry weather road branches to project site.

1.3. Objectives

The main objective of the study is to irrigate 52.5 hectare of land by diverting the river water.

1.4. Scope of the study

The scope of study in this phase covers the following points

- A continues meeting with respective woreda and tabia administrations
- Site selection
- Command area assessments
- River water measurement
- Design of Weir
- Design of Main Canal
- Design of Secondary canal
- Design of Crossing Structures

1.5. Methodology & Materials Used

- hand GPS is used for different measurement and location finding
- A floating method is adapted for base flow measurement
- Google earth is used as a support for command area verification
- 30x30 Tigray DEM is used for watershed delineation
- A proper communication between the users and local officials are held according to the TOR

2. Data required for the study

2.1. Topographic Data

The topographic map of the project area starting from the weir axis up to the tail end of the command area is prepared at a scale of 1:1000. Furthermore a topographic map of 1:500 at the diversion weir axis 200m upstream and downstream is prepared. The river cross-section at the weir axis and both upstream and downstream of this is also surveyed in addition to the river longitudinal profile collected & prepared for the site.

2.2. Watershed Data

In order to determine the design flood of the weir, land use data and its catchment characteristics has been collected from the watershed study report. The land use pattern of the catchments area is as summarized below in table 1.

Table 2-1: Land use Pattern of the Scheme

Land use type	Slope (%)	Area (km^2)	Soil texture/Coverage
Cultivated land	2-8	81.25	Clay
	8-15	110.56	Clay
	15-30	39.29	Clay loam
Grazing land	8-15	0.34	Clay loam
	15-30	29.90	Clay loam
	30-50	7.95	Loam
Forestland (area closures)	8-15	0.73	Clay loam
	15-30	0.49	Loam
	30-50	0.46	silt loam
	>50	0.89	silt loam
Homesteads	2-8	24.70	towns/hard surface
	2-8	1.76	Clay
	8-15	13.37	towns/hard surface
	8-15	1.75	Clay loam
	15-30	1.81	towns/hard surface
	15-30	3.26	Loam
Miscellaneous land	___	4.17	Rock outcrops
Total		**322.68**	

2.3. Geo Technical Data

2.3.1 Foundation Geology

The central part of the weir foundation is formed from a jointed black dolerite rock. The joint has 1m openings and an average spacing of 1.5m and that the river water flows though those structures. From the investigation we understand that the joint structures are shallow in depth, because while we check the amount of water, at the weir axis and 0.5km distance far away at the downstream of the weir axis, it was almost the same. So that it is possible to conclude that the joints have a shallow depth and no or inconsiderable amount of water is expected to be lost through it.

2.3.2 Availability Construction Materials

The availability of construction materials is studied by engineering geologist and it reveals that the construction materials are available in a reasonable distance as indicated below.

S/N	Construction Material Type		Administrative Location				GPS Location			Distance from site	Accessibility	volume in M3	Description
		Woreda	Tabia	Kushet	Got	Site name	X	y	Z				
1	Sand	Enderta	Mahbere Genet	Mesahil	Gogon	Gereb Giba	541692	1504341	1739	3km	accessible	sufficient	Fine to medium size White with black colored sand
2	Stone	Enderta	Mahbere Genet	Mesahil	Genet	Misrar teli river bank	545259	1500331	1883	At the diversion site	accessible	sufficient	Well bedded black limestone

Table 2-2: location of construction materials

2.4. Agronomy Data

As the design of weir head regulator depended on the extent of the area to be irrigated, for the proposed cropping pattern, a peak duty of 1.9 l/s/ha is taken from agronomic study report. (For details refer Agronomy report) for the design purpose 100 l/sec is taken for 52.5 ha.

2.5. Socio-Economic and EIA aspects

Before any intervention is conducted in any development endeavor, social interest, economic viability and other socio economic studies are mandatory. In this particular scheme, socio-economic study and impact assessment has been conducted which reveals that, the study is based on the interest of the local people. For details the socio-economic and environmental impact assessment study reports can be referred.

2.6. Hydrology

The hydrological data analysis is required to deduce the peak design discharged of the river for the 50-year return period flood expected to pass safely over the weir. This maximum design discharge is used in the design not only to determine the stability of the weir section but also to determine the backwater effects of the u/s area due to the construction of the weir. We determined a peak flood using HEC-HMS software.220m3/s of peak flood is used for the design of the weir. For more refer to hydrology report.

3. Diversion & Appurtenant Works across Misrar Teli River

3.1. Diversion Headwork

Diversion is a Structure which is constructed across a river in order to divert water towards the off-taking canal. The various purposes of diversion head works:

- Raise the water level in the river so that sufficient quantity of water can be supplied.
- Regulate the supply of water into the canal.
- Control the entry of silt into the canal.
- Store some water for a short period of time.
- Reduce the water level fluctuations in the river.

3.1.1. Location and Selection of site for headwork

- o Generally located in the boulder or alluvial stage of a river.
- o On alluvial stage is generally preferred unless command of fertile land proposed for irrigation is lost.

3.1.1.1 Site selection criteria for diversion head work:

The site of weir is to be selected from consideration of the suitability for:

- The weir bay section
- The under sluice bay section

An ideal site is that which satisfies requirements for all the three. Each features of the river has to be considered in detail in arriving at the final site. Points to be considered in selecting the site are: course of the river, slope of the river bed, banks, bed width, weir foundation condition, presence of deep channels on the side; the canal is to take off and location of command area. Theoretically the best location for the diversion headwork is at the beginning of the nearby command area. But in areas where this cannot achieved, the diversion site can be moved far upstream at a convenient section. When searching for any work across the river, the engineer has to look for some permanent reach in which the river has not changed its course for many years. Other that need to be considered are:

- Smooth & straight portions rather than meandering portion of river course so as to avoid bank scouring,
- Off-take elevation at the weir site can meet gravity requirement,
- Weir site location is avoided at tributary confluence to prevent the scouring caused by unfavorable flow U/S of the weir,
- The river section at the weir site is narrow, well defined incredible & non submersible bank so that the cost of river training work is minimal,
- Good foundation be available at the site.
- After selecting the weir site depending on the topographic and geological condition, the layout is made considering:
- Reducing engineering quantity & cost of weir, and to enable normal, uniform flow through all bays of the weir with a minimum of shoal formation, the weir is aligned at right angle to the direction of flow in the river (K.R. Arora, 2000).
- To prevent peak discharge scouring near banks of river U/S & D/S of weir during flood period and ensure safety & normal operation of each hydraulic structure, while making general layout, bank protection arrangement on U/S & D/S of the weir is provided based on the geological condition of the river bank at weir site.

3.1.2. Design criteria for Diversion headwork

3.1.2.1 Types of Diversion Head works

Diversion Head Works may be Temporary diversion head works Consists of bund constructed across a river, these bunds may be required to be constructed every year after flood as they may be damaged by the floods. Or may be Permanent diversion head works Consists of a permanent structure such as weir or barrage.

Classification:

Based on foundation type

- Weir on Impervious foundation
- Weir on Pervious foundation

Based on material of construction

- Masonry weirs with vertical drops
- Rock fill weirs with sloping aprons
- Concrete weirs with sloping glacis

Masonry weirs with vertical drops it consists of a horizontal floor and a masonry crest with vertical or nearly vertical downstream face .The raised masonry crest does the maximum ponding of water but part of it usually done by shutter.

Rock fill weirs with sloping aprons such a weir is also called 'dry stone slope weirs consists of a masonry weir wall and dry packed boulders laid in between intervening core walls. D/s slope is generally made very flat. It is the simplest type for construction. Stability is not amenable to exact theoretical treatment (only on the basis of model tests).It requires a very large quantity of stone and is economical only where stone is available in abundance.
Concrete weir with downstream glacis/ogee crest Are of recent origin and their design is based on modern concept of sub-soil flow, i.e. Khosla's seepage theory. Sheet piles of sufficient depths are provided at the u/s and d/s ends of the floor. Sometimes intermediate piles are also provided. Hydraulic jump is developed on the glacis and energy is dissipated. Protective measures like block protection, inverted filter and launching aprons are also provided.

Layout of diversion head works

- Weir
- Divide Wall

- Pocket or Approach channel
- Under sluices or Scouring sluices
- Silt excluder
- Canal head regulator
- River training works (such as Marginal bunds and Guide Bund)

3.2. Hydrology

15 years (2003-2017) of rainfall data of Mekelle is used for peak flood determination. Since the project is a diversion a 50 year return period is adopted. Peak flood is calculated using HEC-HMS software. 220m3/s peak flood is taken for weir design.

3.3. Hydraulic Design of Weir

3.3.1. Weir Crest Length

The length of the Waterway for alluvial rivers is given by Lacey's waterway formula.

$$P = 4.75 * \sqrt{Q}$$

Where, Q= peak flood discharge (220 m^3/s) P= required waterway (m)

$$P = 4.75 * \sqrt{220}$$

$$= 70.5 \text{ m}$$

But, for river, which is deep and narrow, it is better to adopt its natural cross section more over a river with only 29 m wide, this length requires additional excavation. To avoid such excessive work, the weir length has been fixed to be 28.6 m. (I.e. the average natural cross-section of the river.)

3.3.2. Shape of the Weir

Though Ogee shaped weir can have high hydraulic efficiency, it requires costly and sophisticated form works. To avoid such inconveniences and for its practicality, a stone masonry weir with vertical upstream and sloped downstream faces has been recommended. Based on this, the weir is designed as a broad crested weir.

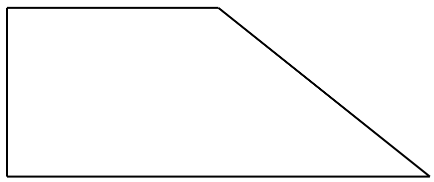


Figure 2: Shape of the weir

3.3.3. Discharge and Head over the Weir

In cases when the under sluice gates are closed, the whole peak flood discharge will flow over the weir crest. Considering such problems the water head over the weir crest is determined by the following formula.

$$Q = C*L*He^{3/2}$$

Where, Q = design discharge

L = Crest length of the weir (effective length)

H_e = Height of energy line above the crest

H_d =Water head over the crest

C = discharge coefficient = 1.7 for broad crested weir.

Q = 220 m^3 /s

$H_e = (Q/CL)^{2/3}$

$= (220/1.7*28.6)^{2/3}$

= <u>2.736 m</u>

3.3.4. Design Head

Head due to approach velocity $h_a = V^2 / 2g$ and this is found by trial and error.

Q = 220 m^3 /s, He = 2.736 P = 0.6 m (assumed) & L (effective) = 28.6 m

Its value is described in Appendix volume.

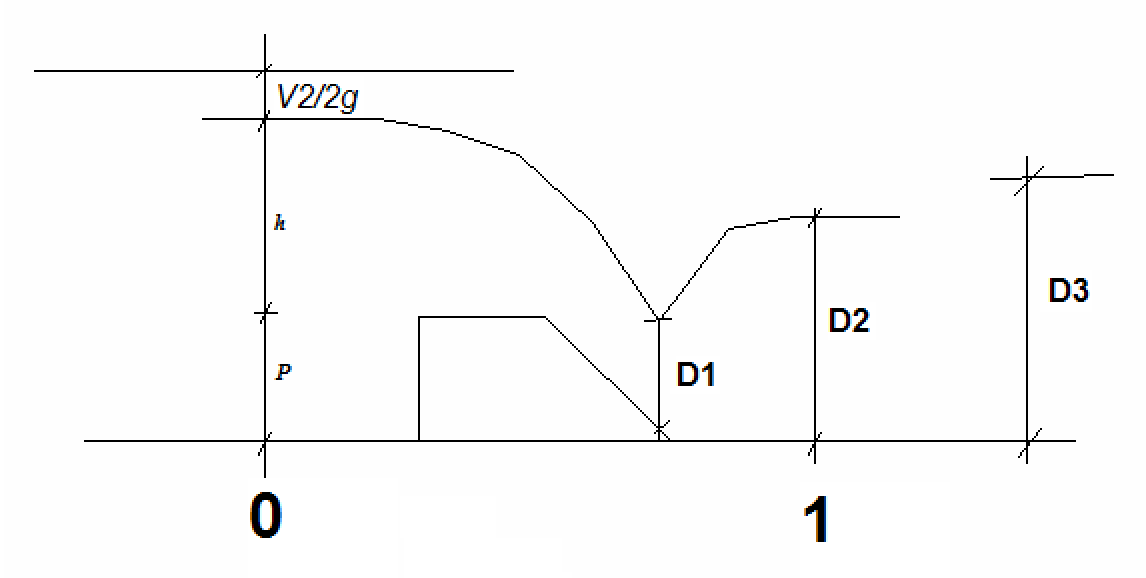


Figure 3: Water Surface Profile

Applying Bernoulli's equation between points 0 & 1,

$Z_0 + P + He - 0.2 = Z_1 + D_1 + (V_1^2/2*g) + H_L$

For horizontal surfaces $Z_0 = Z_1$ & H_L are negligible.

$0.6 + 2.736 - 0.2 = D_1 + (V_1^2/2*g)$ and $V_1 = Q/LD_1$

By trial & error $D_1 = 1.11$ m

Velocity at the toe of the weir, $V_1 = Q/LD_1 = 220/28.6*1.11 = 6.94$m/s

$$F_1 = V_1/\ (g*D_1)^{1/2} = 2.1$$

$$D_2 = 0.5*D_1*((1+8F_1^2)^{1/2}-1) = 2.345\text{m}$$

3.3.5. Weir Crest Elevation

The weir height has been determined on the basis of the canal off take level and the head required to deliver the canal with the design discharge.

$\sigma_0 = P + H_d - D_3$

Where, σ_0 = Afflux over the normal water depth at the weir site, m

P = Weir height, m

H_d =head over the crest

D3 = normal water depth

Thus the U/S and D/S total energy level, TEL and U/S highest flood level is computed. For more detail see figure in annex

Therefore, the assumed weir height 0.6 m is adopted. For more detail see figure in annex.

3.3.6. Water Surface Profile at the Weir Site.

The water surface profile computation both U/s and D/S of the weir site is crucial in the design of diversion weirs. The profile U/s and D/S of the weir is determined as follows.

3.3.6.1. Water Surface Profile Downstream of the Weir

This profile is used to structurally design the weir, downstream protection works and the downstream wing walls.

As computed earlier D_1= 1.11 m & D_2 = 2.345 m

Thus Length of the jump, $L_j = 6*(D_2 - D_1)$

$= 7.5m$,

For safety reasons let's take 10% increment and hence, L_j = 8.25 therefore, take L_j = 9 m.

Water surface level at downstream of the weir = (Sequent depth) or (tail water depth + depressed depth) + Freeboard (F_b), whichever is greater. For a detail see annex volume

3.3.6.2. Water Surface Profile U/S of the Weir

The back water effect due to construction of the weir is required to determine the level of the water surface at different lengths U/S of the weir .The computation is needed to determine whether the flood overtops the river banks and up to what length should it extend, thereby to provide protection measures.

Using the approximate method.

$$Y = \frac{(XS-2\Delta o)^2}{4\Delta o}$$

Where: Y = water rise at distance X upstream of the weir above the normal water depth.

X = Distance from the crest to the point where y is required to be determined.

S = Slope of the river bed (0.033212).

Δo = Rise of water above the normal water depth at the weir site.

The normal water depth from the rating curve is determined to be about 2.1 m.

Δo= 2.4 m (determined earlier)

$$\text{Thus, } y = \frac{((0.033212*X)-(2*2.4))^2}{4*2.4} = 0$$

X = 150 m

Therefore, the effect construction of weir on the water profile during peak floods ceases at 150 m away from the axis. The right and left side U/S abutment are stable; hence the length of wing wall provided is 4 m.

3.3.7. Divide Wall

A divide wall is a wall constructed to the direction of flow of the river to separate the weir proper section and the under sluices section. The divide wall should extend on the U/S to the point opposite to the head regulator. On the D/S it usually extends up to the end of riprap. It is made of masonry, the top width being kept between 1 m - 2.5 m.

For this particular scheme a top width of 1 m with downstream length of 2.5 m and u/s length 1.0 m has been provided.

3.3.8. Head Regulator

The canal head regulator is a structure constructed at the head of the off taking canal u/s of the weir axis. It has the following functions.

1. It regulates the supply of water in to the canal.
2. It controls the entry of silt in to the canal.
3. It excludes the high flood from entering the canal.

To provide smooth entry of water, the head regulator is aligned at 145^0 to the axis of the weir and at an elevation of 1861.1 m. To minimize the entry of silt in to the canal, its crest is fixed to be 0.1 m above the sluice way sill level. For Misrar teli river diversion scheme pipe culvert intake type of regulator is provided. In designing such an intake it is assumed that the pipe is fully flowing with both ends submerged. To prevent the intake from being clogged by debris and silt the pipe diameter should be 0.4 m, therefore, 0.4 m diameter RCC pipe with trash rack bars in front of it have been provided on the right flank.

The pipe intake is designed as an orifice.

$$Q = C_d A\sqrt{2gh}$$

To determine the gate opening area, H has to be determined. Therefore, the hydraulic losses in the head regulator are calculated in the following table.

Table 3-1: Hydraulic Losses with in the Head Regulator

Case II: Design of Head regulator/Intake if pipe						
Assume, diameter d (m) =	0.4	Assumed				
Pipe length, Lp (m)=	2.0	From topo				
Roughness coefficient concrete for pipe, n =	0.014					
Intake capacity, Q (m3/s)=	0.1000					
Intake loss, h= $(v^2/2g)*F_T$, where FT= (Entry loss +Friction loss(FL) + Exit loss) coefficients						
Entry loss =	0.5					
Exit loss =	1					
Friction head (FL) = fL/D and $f=124.5n^2/D^{1/3}$	0.03311861					
Thus headloss due to friction, FL = fL/D	0.16559305	m		C= 0.62		
Thus F_T	1.66559305					
Area of flow, A (m2)=ΠD2/4 =	0.1256	Velocity of flow, V (m/a) =Q/A,				0.7962
		Therefore, head, h= $(V^2/2g)*F_T$ =				0.053813
		Check: this capacity using orifice formula				
		$Q_{intake}=C*A*(2gh)^{1/2}$, Where: C is orifice coefficient=0.81 for circular intake				
			0.1045369	m3/s		
			Ok			

Gate and Accessories

Trash rack

A trash rack of 10 mm diameter steel bars of 5 cm center to center spacing is provided at the intake with 0.6 m x 0.6 m dimensions placed in front of the gate.

The gate

The Gate to be provided in the head regulator and under sluice is flat gate to be constructed out of steel. The diameter of spindles and thickness of the steel plate is designed so it can protect itself from incoming pressure.

More on structural design of head regulator see on annex volume.

The geometrical dimension of the head regulator gate is 0.6 m width X 0.6 m height.

3.3.9. Design of under sluice.

This structure is provided to protect and remove sediment deposition near by the intake canal and thereby preventing it from entering the off take canal. The under sluice bay is located to the same side of the off taking canal to maintain well defined canal section towards the canal head regulator. Moreover, it is helpful in lowering the high flood level by supplementing the flood discharging over the weir. Usually the width of under sluice portion shall be determined so that it is capable of passing 10-20 % of the incoming river flood (i.e. the peak flood discharge).but in our case the width of the abutment is small comparing to the peak flood. With this width we can only able to pass 2% of peak flood (4.4m3/s).with that discharge we have provided three sluice gates with a dimension of (1m width and 0.6m depth).if we have to pass a total of 10% ,15 sluice gates required For more detail see annex volume.

3.4. Structural design of the weir

Structural stability is checked. The dimension of the weir is set to be safe against sliding, overturning, tension and contact pressure. See the structural stability analysis on the annex volume.

3.5. Design of Cutoffs and Impervious Floor

3.5.1. Cutoff

Usually, cement masonry vertical cutoffs have been recommended at both ends of the impervious floor. These structures are provided so as to protect the structure from undermining of the foundation and to reduce the exit gradient.

As per Lacey's theory, the regime scour depth R is given by: - $R = 1.35\ (q^2/f)^{1/3}$

The place where the weir is about to build has a massive rock foundation. Due to this cutoff is not required.

3.5.2. Thickness of impervious Floor

3.5.2.1 Upstream Floor Thickness

The uplift pressure on the upstream floor is counterbalanced by the static head of water on the weir. Thus, the nominal floor thickness of 0.5 m is provided in case of masonry floor.

3.5.2.2 Downstream floor thickness

The natural ground for most section of the river doesn't require an apron due to its good foundation. The downstream is a natural energy dissipater by itself. But for a leveling Purpose we fill the cistern length with concrete till elevation 1860.8. We have provided an average of 0.6 m thickness apron.

3.5.2.3 Estimation of Length of Stilling Basin

To ensure safety against piping, Lane's Weighted Creep Theory states that "The sum of the vertical creep lengths, plus one third the sum of the horizontal creep lengths must be greater than the differential head across the structure times Lane's creep coefficient (C)".

The downstream cistern i.e. solid apron should be long enough to accommodate the jump and is 5 to 6 times jump height i.e.

L_j = 5 to 6*(d_2-d_1)

This length could be reduced by providing a stilling basis with different energy defusing elements, i.e. chute blocks, friction block, arrow, dented sill, deflector, biff wall ribbed pitch, baffle wall, etc

As calculated earlier at section 2.3.6 a 9 m long concrete apron is provided to ensure the incoming flood don't make devastated impact over the structure.

3.6. Design of Protection Works

The structure must be well protected from river over flow and creep along the walls must be prevented. But in this particular site protection works is not required considering its sound rock formation.

3.7. Retaining Walls

3.7.1. Wing Wall

The maximum and the top level of the wing wall are a function of the weir height, head over the weir and the allowable free board. 3.8 m is provided for upstream and 3.3 m for downstream. For more detail see annex figure

4. Irrigation infrastructure design

4.1. Catchment water planning

4.1.1. Stream Flow Data

Msrar Teli stream is not gauged. In order to know the potential of the stream, it is a procedure to collect the lean flow at different months of the year in general and in the dry months in particular but for misrar teli diversion irrigation project the measurements are taken for two months only during field study. The measurements are conducted using floating method, on month November and December as presented in the following table. To increase the dependability of the design inputs, experts from the Woreda and the local farmers were consulted, as a result they witnessed that the river is perennial.

Table 4-1 Flow Measurement

Date of measurement	Discharge(l/s)
10/11/2017 G.C	204
11/12/2017 G.C	196

For the computation of the catchment water balance, it was assumed that, the flow will decrease linearly throughout the periods of no measurement. For design of the Msrar Teli diversion we take the last day measured discharge which is 196 l/s.

4.1.2. Water Balance Computation

To undertake estimates of the water balance for un-gauged catchment is not an easy task. However, efforts have been made to have some estimates by interview of the farmers. Furthermore, the catchment area has been visited to have an observation, if either traditional or modern irrigation schemes exist on upstream and or downstream of the weir axis. As a result, there is modern irrigation diversion scheme downstream of the Msrar Teli headwork location. The downstream diversion (tslwe) is designed for 30hectars but the farmers irrigate 35 hectares measured during field study for Msrar Teli diversion.

- The flow measurements have been made using floating method only twice in the months of November and December.
- It is assumed that, the flow is distributed linearly for the rest unmeasured months because we consult farmer's senior in traditional irrigation from Msrar Teli. River.
- Command area has been determined for the capacity of the river without any deficit of water.
- As a result of sufficient flow of Msrar Teli River the duty is calculated using 12hours operating time.
- The duty of Msrar Teli irrigation is 1.9 l/s/hectares taken from agronomy report.
- Command available 52.5 hectares
- Total needed water for Msrar Teli=99.75 l/s approximately 100 l/s from the lean flow measured during field work using the float method the 196 l/s the 100 l/s has been used for a capacity of irrigating 52.5ha using the duty 1.9 l/s/hectares, the rest flow is left for the existing downstream diversion Tslwe and downstream biodiversity.

Table 4-2 water demand and supply summary table

Taking lean flow 196l/s measured at 11/12/2017 GC						
Month	**lean flow(m3)**	**downstream release 25% (m3)**	**35 ha Tslwe irrigation Demand(m3)**	**52.5 ha Msrar teli irrigation demand(m3)**	**Total Demand(downstream release 25% + Tslwe + Msrar teli)**	**Water availability**
December	275184	68796	57015	85522.5	211333.5	Excess
January	275184	55036.8	84560	126840	266436.8	Excess
February	275184	41277.6	91525	137287.5	270090.1	Excess
March	275184	68796	65870	98805	233471	Excess
April	275184	68796	30275	45412.5	144483.5	Excess
May	275184	68796	27265	40897.5	136958.5	Excess

Taking lean flow 196l/s measured at 11/12/2017 GC						
Month	**lean flow(m3)**	**downstream release 25% (m3)**	**35 ha Tslwe irrigation Demand(m3)**	**52.5 ha Msrar teli irrigation demand(m3)**	**Total Demand(downstream release 25% + Tslwe + Msrar teli)**	**Water availability**
June	275184	68796	0	0	68796	Excess
July	275184	68796	4480	6720	79996	Excess
August	275184	68796	63945	95917.5	228658.5	Excess
September	275184	68796	37275	55912.5	161983.5	Excess
October	275184	68796	22365	33547.5	124708.5	Excess
November	275184	68796	35840	53760	158396	Excess

4.2. Hydraulic design of Canal

4.2.1. Fixing Main Canal Capacities

Considering different parameters the crop water requirement (duty) calculated is 1.9 l/s/hectare. This duty is the maximum duty at the dry season taken from the Agronomist study. Canal capacity is fixed based on the command area that is delivered by the canal.

Canal discharge = duty* irrigated area.

Q = 1.9 *A

= 1.9*52.5 =99.75 l/s

Therefore, for design use **100 l/s**

The whole command area is divided in to several secondary units (farm blocks).

4.2.1.1 Design of Open Canals (Canal Cross-Sections)

Design considerations:-

- Manning's roughness coefficient, **n:0.018**
- Velocity, v: 0.5-2m/s lined canal **0.7m/s** for Msrar teli
- b/d ratio: 1

The design of open canals is concerned with the determination of the cross sectional dimensions of the canal to convey the required amount of discharge intended to meet the peak requirement of crops grown in the entire command area during the supplementary case and dry season cases. For Msrar teli diversion irrigation project the rectangular lined canal is selected because the route of the main canal have permeable soil and hilly as indicated in geological report.

The dimension of the canal can be calculated using the general formula of Manning's, which is given by:

$Q = A*V$ And V=(R^2/3*S^1/2)/n

Taking v=0.7 m/s, longitudinal Slope=0.0025 $R = (\frac{v*n}{S^{1/2}})^{3/2}$ =0.13

Where, Q = discharge of the canal

A = Wetted cross-sectional area =0.1

S = bed slope=0.0025

n = Manning's roughness coefficient=0.018

Then calculating using all the inputs for canal design the canal parameters are

Bed width (b) =0.4m

Depth (d) =0.4m

Total depth =depth of water +free board=0.2+0.4=0.6m

Total depth of masonry=0.4+0.2=0.6m

Total width of masonry=floor width (0.3m) +2*wall thickness (0.3m) =0.9m

Free board =0.2m for Q less than 0.1 m^3/s

Wall thickness of the canal is 0.3m and

As the geological formation along the canal routes is pervious, a rectangular masonry section is provided for all the main canal which do not involve any formwork and the beneficiaries can easily maintain it.

4.2.2. Design of Secondary Canals

The design of the secondary canals capacity is based on the command area to be irrigated. In this specific scheme we have three secondary canals.

Table 4-3 Command area bounded by each secondary canal

SC No.	Command Area (A) Bounded (ha)	Duty (l/s/ha)	Q_{req} (m^3/s)=Duty*A
SC-1	12.00	1.9	0.02280
SC-2	17.86	1.9	0.03393
SC-3	18.34	1.9	0.03485

4.2.2.1 Design of Masonry Lined Canal Section secondary canal-1

Design parameter

- Manning's roughness coefficient, **n:0.018**
- Velocity, v: 0.5-2m/s lined canal **1.35m/s** for Msrar teli
- b/d ratio: 1

Command area in ha=12.00

Maximum duty in lit/sec/ha= (1.9) taken from agronomy report

Design discharge, Q = Duty*area =1.9l/s/ha*12ha=**0.023m³/s**

The dimension of the canal can be calculated using the general formula of Manning's, which is given by:

$Q = A*V$ And V=(R^2/3*S^1/2)/n

Taking v=1.35 m/s, longitudinal Slope=0.0388 $R = (\frac{v*n}{S^{1/2}})^{3/2}$ =0.13

Where, Q = discharge of the canal

A = Wetted cross-sectional area =0.1

S = bed slope=0.0388

n = Manning's roughness coefficient=0.018

Then calculating using all the inputs for canal design the canal parameters are

Bed width (b) =0.13m

Depth (d) =0.13m

Total depth =depth of water +free board=0.2+0.13=**0.33m**

Total depth of masonry=0.13+0.2=0.33m

But the width calculated using the inputs is too small, it is difficult to clean the canal when silted up. Considering this the canal width is adopted to be **0.3m.**

Total width of masonry=floor width (0.3m) +2*wall thickness (0.3m) =0.9m

Free board =0.2m for Q less than 0.1 m^3/s

Wall thickness of the canal is 0.3m and

As the geological formation along the canal routes is pervious, a rectangular masonry section is provided for all the secondary canal-1 which do not involve any formwork and the beneficiaries can easily maintain it.

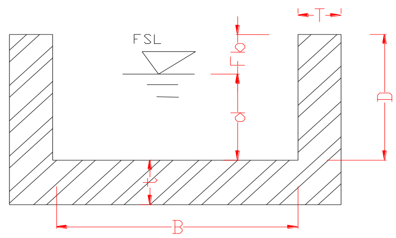


Figure 4: X -section of Masonry Lined Canal

(Design of parameters is done using excel and the computation is annexed)

4.2.2.2 Design of Masonry Lined Canal Section secondary canal-2

Design parameter

- Manning's roughness coefficient, **n:0.018**
- Velocity, v: 0.5-2m/s lined canal **1.57m/s** for Msrar teli
- b/d ratio: 1

Command area in ha=17.86

Maximum duty in lit/sec/ha= (1.9) taken from agronomy report

Design discharge, Q = Duty*area =1.9l/s/ha*17.86ha=**0.034m³/s**

The dimension of the canal can be calculated using the general formula of Manning's, which is given by:

$Q = A*V$ And V=(R^2/3*S^1/2)/n

Taking v=1.57m/s, longitudinal Slope=0.0388 $R = (\frac{v*n}{S^{1/2}})^{3/2}$ =0.05

Where, Q = discharge of the canal

A = Wetted cross-sectional area =0.02

S = bed slope=0.0445

n = Manning's roughness coefficient=0.018

Then calculating using all the inputs for canal design the canal parameters are

Bed width (b) =0.15m

Depth (d) =0.15m

Total depth =depth of water +free board=0.2+0.15=**0.35m**

Total depth of masonry=0.15+0.2=0.35m

But the width calculated using the inputs is too small, it is difficult to clean the canal when silted up. Considering this the canal width is adopted to be **0.3m.**

Total width of masonry=floor width (0.3m) +2*wall thickness (0.3m) =0.9m

Free board =0.2m for Q less than 0.1 m^3/s

Wall thickness of the canal is 0.3m and

As the geological formation along the canal routes is pervious, a rectangular masonry section is provided for all the secondary canal-2 which do not involve any formwork and the beneficiaries can easily maintain it.

(Design of parameters is done using excel and the computation is annexed)

4.2.2.3 Design of Masonry Lined Canal Section secondary canal-3

Design parameter

- Manning's roughness coefficient, **n:0.018**
- Velocity, v: 0.5-2m/s lined canal **1.6m/s** for Msrar teli
- b/d ratio: 1

Command area in ha=18.34

Maximum duty in lit/sec/ha= (1.9) taken from agronomy report

Design discharge, Q = Duty*area =1.9l/s/ha*18.34ha=**0.035m³/s**

The dimension of the canal can be calculated using the general formula of Manning's, which is given by:

$Q = A*V$ And V=(R^2/3*S^1/2)/n

Taking v=1.6 m/s, longitudinal Slope=0.0388 $R = (\frac{v*n}{S^{1/2}})^{3/2}$ =0.05

Where, Q = discharge of the canal

A = Wetted cross-sectional area =0.02

S = bed slope=0.046

n = Manning's roughness coefficient=0.018

Then calculating using all the inputs for canal design the canal parameters are

Bed width (b) =0.15m

Depth (d) =0.15m

Total depth =depth of water +free board=0.2+0.15=**0.35m**

Total depth of masonry=0.15+0.2=0.35m

But the width calculated using the inputs is too small, it is difficult to clean the canal when silted up. Considering this the canal width is adopted to be **0.3m.**

Total width of masonry=floor width (0.3m) +2*wall thickness (0.3m) =0.9m

Free board =0.2m for Q less than 0.1 m^3/s

Wall thickness of the canal is 0.3m and

As the geological formation along the canal routes is pervious, a rectangular masonry section is provided for all the secondary canal -3 which do not involve any formwork and the beneficiaries can easily maintain it.

(Design of parameters is done using excel and the computation is annexed)

4.2.3. Longitudinal Section of Canals

The longitudinal section along the canals is prepared with levels at intervals based on the natural topographic changes indicating the following details:

- Chainage
- Existing ground level (OGL)
- Canal bed level (CBL)

- Full supply level (FSL)
- Canal top level (CTL)

The longitudinal profile of the main canal and secondary canals is shown in the drawings.

4.2.4. Canal structure

4.2.4.1 Drops

Whenever the natural ground profile is steeper than the design canal bed slope, drops have to be provided to avoid high falling. The ground slope along the canals in the project area is generally steeper than the water surface slope which is required to limit the flow velocity. Hence, providing a fall is imminent to secure lowering of the water surface in a canal and to dissipate the energy liberated. Fall is located at a point upstream where the full supply level exceeds the natural ground level such that the drop structure is positioned in cutting than in fill. Vertical drop type is selected since the discharge through the canal system is small. Only, 1.5m and 0.5m vertical drop height are provided for ease of construction in most part of the canal.

The design has been carried out by the procedures shown below using excel sheet, the computation of volume of masonry work, excavation work, plastering work and backfill work are also done.

Design Procedure

Drops structures are provided at both the main canal secondary canals of the irrigation system. The drops are designed by the following equation:

1. Volume of basin:

$$V = \frac{Q * H_d}{150}$$

Where, Q= design discharge (l/s)

H_d = height of drop (u/s FSL-d/s FSL)

2. Depth of Cushion Chamber:

$X = d + 0.82*d^{1/3}*Hd^{1/2}$ =0.72m

Where, X = depth of cushion chamber below d/s FSL

d = U/s full supply depth

H_d = height of drop

3. Length of Basin (Y):

$$Y = 4/3*(Z*d)^{½}$$

Where, z = difference between crest & bottom of cushion

= X + Hd – d

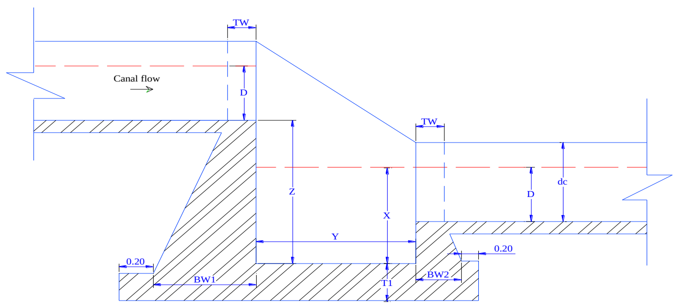


Figure 5: longitudinal Section of typical drop structure

4. Width of Basin (W):

$$W = V/\{Y (d_B+d)\}$$

Where d_B = depth of basin

5. Wall Extension Length:

Lu =Ld = d+Fb

6. Wall Base Width:

$$Bw1 = \frac{(Z+d)}{\sqrt{p \square 1}}$$

$$Bw_2 = \frac{X}{\sqrt{p \square 1}}$$

Where, ρ = Unit weight of wall material (2.5 for masonry)

7. Length of u/s apron, L & d/s apron, M:

For all HD, L = 3.0m & M= 6.0m

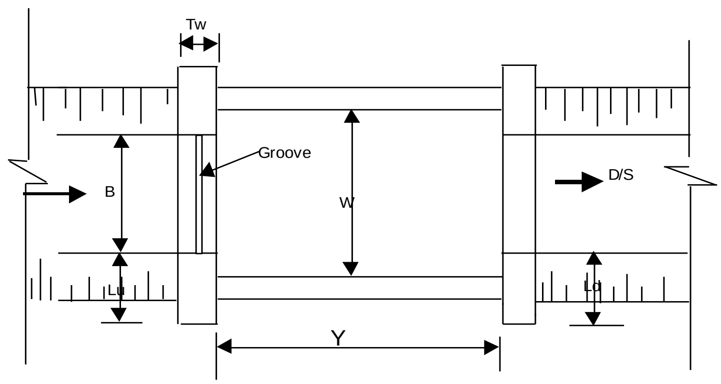


Figure 6: Plan View of typical drop structure

8. Cushion Floor Thickness

A nominal thickness of 0.3m is provided

9. Thickness of wall (Top width of wall), Tw.

The top width of the wall is determined to be 0.3m

The dimensions of the drops in the secondary canals are determined in the same way.

Table 4-4 summary of drop structure in main canal and secondary canals

DIMENSION OF DROP STRUCTURES 0.5m drop				
	0.5m DROP			
	MC	**SC-1**	**SC-2**	**SC-3**
TW	0.3	0	0	0
dc	0.58	0	0	0
m	0	0	0	0
BW1	0.46	0	0	0
BW2	0.40	0	0	0
X	0.80	0	0	0
Y	0.78	0	0	0
Z	0.92	0	0	0
W	0.53	0	0	0
F	0.20	0	0	0
D	0.38	0	0	0
T1	0.30	0	0	0
B	0.38	0	0	0
1.5m DROP				
	MC	**SC-1**	**SC-2**	**SC-3**
TW	0.3	0.3	0.3	0.3
dc	0.58	0.33	0.35	0.35
m	0	0.00	0.00	0.00
BW1	1.11	1.00	1.02	1.02
BW2	0.40	0.40	0.40	0.40
X	1.10	0.64	0.68	0.68
Y	1.22	0.68	0.73	0.73
Z	2.23	2.01	2.03	2.03
W	0.53	0.53	0.69	0.71

DIMENSION OF DROP STRUCTURES 0.5m drop				
F	0.20	0.20	0.20	0.20
D	0.38	0.13	0.15	0.15
T1	0.30	0.30	0.30	0.30
B	0.38	0.30	0.30	0.30

Table 4-5 drop location in main canal and secondary canals

Drop type	Chainage in main canal	Chainage Location in SC-1	Chainage Location in SC-2	Chainage Location in SC -3
0.5m	781,1016,1950m			
1.5m	445,538,558,615,705,1918, 1945,2000m	180,219,399,459m	0.0,80,140,198,355m	20,100,120,335m

4.2.4.2 Design of Division Structures (Division Box & Turn Outs)

This structure must divert exactly the amount of water, which has to flow in the branching out flow channel and the water, which is continuing its direction.

Division structures are provided at the canal system, which are used to divide the flow from the main canal to secondary canal and from these secondary canals to several tertiary canals. The division boxes are designed to divert flow to each canal on proportional bases during the maximum flow and on rotational bases during the low flow (when the flow is less than the design flow of the canal).

Tertiary and field canals are not provided, simple turnouts at the secondary canals, which directly take flow to the fields are provided. These turnouts are provided on the secondary canals based on the available command area and topography. At every 100 -200m distance on the secondary canal, one turn out is provided.

The flow at each turn out (to each canal) is controlled by gate operation

There are three division boxes and they are designed proportionally according to discharges in both parent and off take canals.

Table 4-6 Table of Dimensions of division boxes

Division Box	Parent and Originating Canals	Chainage(m)	L_1(m)	L_2(m)	L_3(m)	D(m)	b(m)	B(m)
DB1	MC to (SC-1 & SC-2,SC-3)	2+307	1.30	0.30	0.00	0.33	0.30	1.00
DB2	MC to (SC-2 & SC-3)	2+677	0.80	0.40	0.00	0.35	0.30	1.00
DB3	MC to SC-3	2+677	0.40	0.40	0.00	0.35	0.30	1.00

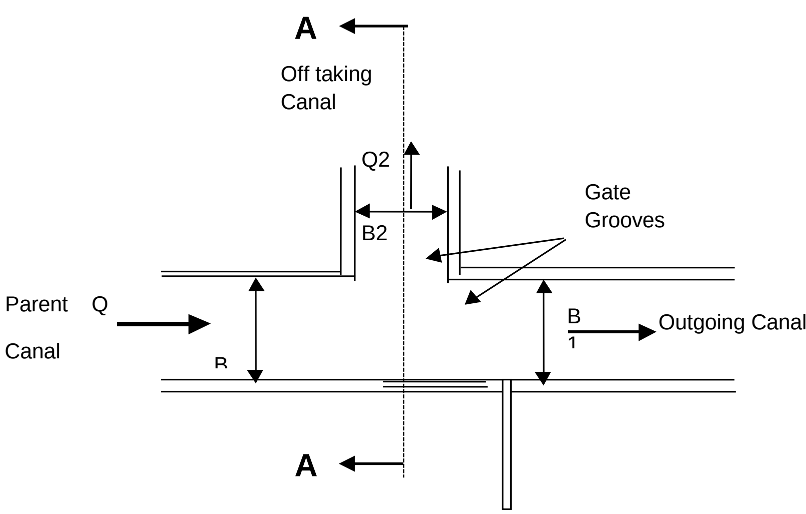


Figure 7: Plan View of typical Turn Outs

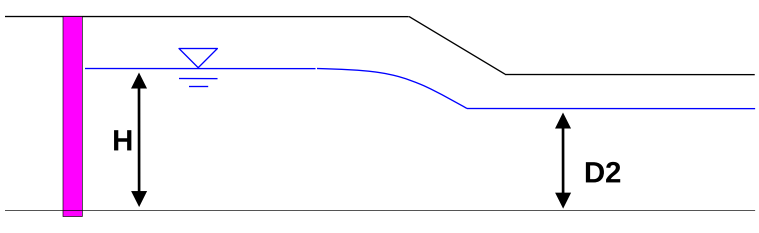


Figure 8: Sections A-A of the typical Turnouts

4.2.5. Crossing structures

In this irrigation scheme the canal route goes through steep ground, crosses a numbers of drains and footpaths, which needs different types of structures. These structures include:

- Reinforced concrete flume (aqueduct)
- Supper passage (water is to be conveyed pipe system) for road crossing
- foot paths

Design is made based on their design parameters and detail drawings are shown in the working drawing.

4.2.5.1 Foot Path Crossing

There are footpaths at the main canal and secondary canal system of the Msrar Teli irrigation scheme. The footpath is used to cross animals from one area to another, which has 1.5 m width and 5cm thickness slab at every 200m distance in the secondary canals and three foot path crossing in main Canal. The bar arrangement for the slab is one way mesh with 8mm diameter at 20cm spacing for both sides.

4.2.5.2 Road Crossing

There is one road crossing in the main canal and for this crossing RCC pipe 400mm diameter is selected.

4.2.5.3 Gully Crossing

In the whole canal system of the Msrar Teli irrigation project, there are Aqueduct (RCC flume) Gully crossings in main canals at various chainage.

Design is made based on design parameters and detail drawings are shown in the working drawing part of the engineering report.

5. Bill of quantity and Cost Estimation

Most of the quantity is incorporated in table below on the consultant's experience in the field work of final design report of the feasibility study and the unit price for civil works taken from construction, Road and Transport Bureau.

Table 5-1 BOQ Summary

	Summary	
ITEM No.	**DESCRIPTION**	**AMOUNT(ETB)**
1	Total cost of General item	208,000
2	Total cost of Headwork	778,248
3	Total cost of infrastructure	9,636,678
4	Total cost of the project	10,622,926
5	VAT (15 % of the project cost)	1,593,439
6	Grand total cost of the project	**12,216,365**

Table 5-2 BOQ for General Item

ITEM No.	DESCRIPTION	UNIT	QNTY	RATE(ETB)	AMOUNT (ETB)
	BOQ for General Item				
1	Mobilization & demobilization of machinery and equipment	Ls	1	50,000.00	50,000.00
2	Construction of contractor's camp or temporary residence from G-32 CIS and that has to be handed over to the IWUA at the end of the construction. The rooms are well ventilated equipping with windows and doors of the same material as per given drawings. The camp should be constructed at the appropriate place for camping and IWUA purpose.	Ls	1	150,000.0 0	150,000.00
4	Supply and install 2*1m rectangular metal sign board with 60*60*3mm RHS frame, 1.5mm thick metal sheet at both sides and 2Ø4inch GS pipe post for the purpose of scheme information as specified by the Engineer. Price includes all necessary cutting, welding, painting, writing works on both sides & C-10 concrete for foundation fill.	Ls	1	8,000.00	8,000.00
	Total cost of general and preparatory works				**208,000.00**

Table 5-3 Total Quantity for Msrar teli Headwork

Description	Unit	Rate	Quantity	Total Cost
HEADWORK				**778,247.98**
1. Earth Works				**80,429.12**
1.1 Overall site clearance				**4,506.94**
1.1.1 Site clearance(10cm)	m2	17.24	150	2,586.00
1.1.2 Cart away(will be dumbed with in 1km)	m3	178.36	10.77	1,920.94
1.2 Overall Excavation (at all formation)				**75,922.19**
1.2.1. Upstream wing walls				
1.2.1.1 Excavation	m3	229.81	54	12,409.74
1.2.1.2 Cart away(will be dumped within 1 km)	m3	178.36	27	4,815.72
1.2.2. Downstream wing walls				
1.2.2.1 Excavation	m3	229.81	66	15,167.46
1.2.2.2 Cart away(will be dumped within 1 km)	m3	114.91	33	3,792.03
1.2.3. Upstream Apron				
1.2.3.1 Excavation	m3	229.81	17	3,906.77
1.2.3.2 Cart away(will be dumped within 1 km)	m3	178.36	8.5	1,516.06
1.2.4. Downstream Apron				
1.2.4.1 Excavation	m3	229.81	63.8	14,661.88
1.2.4.2 Cart away(will be dumped within 1 km)	m3	178.36	31.88	5,685.23
1.2.5. Under Weir Body				
1.2.5.1 Excavation	m3	229.81	43.8	10,065.68
1.2.5.2 Cart away(will be dumped within 1 km)	m3	178.36	21.88	3,901.63
2. Masonry works 1:3(cement sand ratio)				**256,032.06**
2.1 u/s wing walls	m3	1073.96	86.4	92,790.14
2.2 d/s wing walls	m3	1073.96	110	118,135.60
2.3 u/s Apron	m3	1073.96	17	18,257.32
2.4 weir body	m3	1073.96	25	26,849.00

Description	Unit	Rate	Quantity	Total Cost
3. Concrete works (C-25)				**284,813.39**
3.1 weir body foundation	m3	2531.7	36.7	92,913.39
3.2 for d/s apron	m3	2532	75	189,900.00
3.3 concrete pipe 40 cm,1m	Pcs	1000	3	3,000.00
4. Back fill with ordinary soil & compaction on outer face of wing walls	**m3**			**36,066.80**
4.1 Back fill with ordinary soil & compaction on outer face of u/s wing walls	m3	257.6	63	16,230.10
4.2 Back fill with ordinary soil & compaction on outer face of d/s wing walls	m3	257.6	77	19,836.70
5. Plastering(1:3)				**47,176.60**
5.1 plastering of weir body	m2	105	107.3	11,261.30
5.2 plastering of u/s retaining wall	m2	105	113.4	11,907.00
5.3 plastering of d/s retaining wall	m2	105	185.2	19,440.80
5.4 Plastering of u/s apron	m2	105	43.5	4,567.50
6. Gate Installation & trash rack				**22,000.00**
6.1 Sliding intake gate supply and Installation 0.6m wide by 0.6m height including runners within both grooves	Pcs	5000	1	5,000.00
6.2 Sliding sluice gate supply and Installation for sluices, 1.1 m wide by 0.65m height	Pcs	5000	3	15,000.00
6.3 trash rack of 10mm diameter c/c 5cm a dimension of 0.6m*0.6m	pcs	2000	1	2,000.00
7.Reinforcement				**51,730.00**
7.1 RF bar of ø10 @200mm	kg	43	610	26,230.00
7.2 RF bar of ø12 @200mm	kg	40	637.5	25,500.00

Table 5-4 Total Quantity for Msrar teli infrastructure

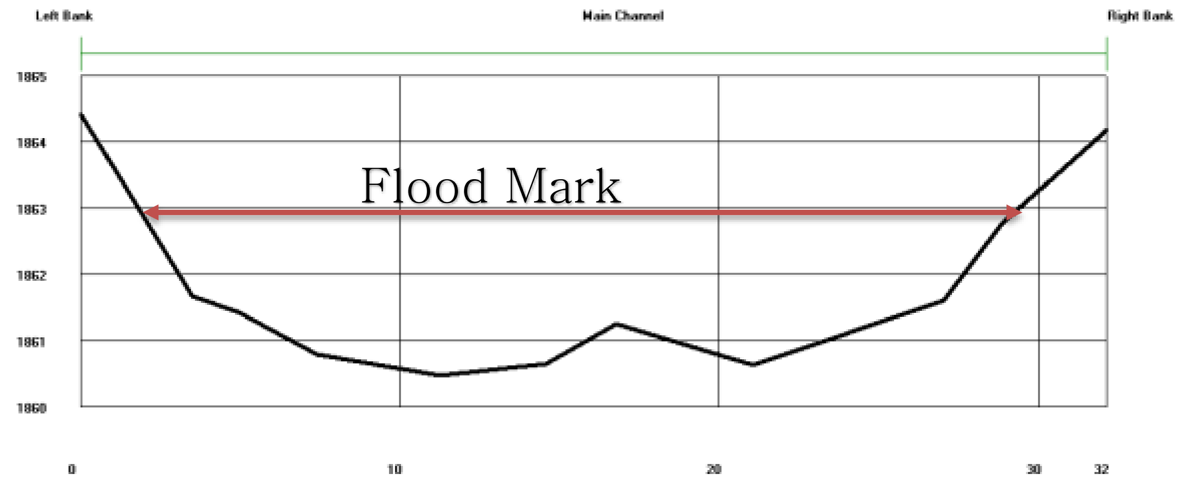
	Total Quantity For Msrar teli infrastructure				
1	**Main Canal**	**Unit**	**Total Volume**	**unit rate**	**Total Birr**
1.1	Site clearing up to 20cm	m2	9090.00	17.24	156711.60
1.2	Excavating at all formation to the levels, widths & grades as shown on the drawings or as directed by the engineer	m3	5302.86	229.81	1218651.17
1.3	20cm thick hard core under base	m3	238.19	250.00	59548.49
1.4	Total masonry Work for main canal with cement to sand ratio 1:3	m3	316.83	1073.96	340262.75
1.5	20 mm thick cement mortar plastering with cement to sand ration 1:3 to the bed & vertical sides & top surfaces of the canal, including the chute sections	m2	7522.91	128.38	965791.19
1.6	slabe cover(C-25) to protect main canal from flood from chainage 0+000 to 0+280 size of slabe 0.9m*.5m and thickness 0.15 as indicated in drawing	m3	37.80	2531.70	95698.26
1.7	Back fill	m3	3165.97	257.60	815553.87
				SUM	**3652217.33**
3	**Secondary Canal**				
3.1	Site clearing	m2	4488.00	17.24	77373.12
3.2	Excavating to the levels, widths & grades as shown on the drawings or as directed by the engineer	m3	9875.30	229.81	2269442.20
3.3	20cm thick hard core under base	m3	82.33	250.00	20583.34
3.4	Total masonary Work cement to sand ratio 1:3	m3	748.28	1073.96	803621.93
3.5	20 mm thick cement mortar plastering with cement to sand ration 1:3 to the bed & vertical sides & top surfaces of the canal, including the chute sections	m2	2443.63	128.38	313713.38
3.6	Back fill	m3	1015.98	257.60	261717.03
				SUM	**3746450.99**
4	**Division Box**				
4.1	Excavation work	m3	14.00	229.81	3217.54

	Total Quantity For Msrar teli infrastracture				
1	**Main Canal**	**Unit**	**Total Volume**	**unit rate**	**Total Birr**
4.2	massonary work cement to sand rario 1:3	m3	9.47	1073.96	10174.40
4.3	stone pitiching work	m3	9.94	250.00	2485.67
4.4	Plastering work cement tosand ratio 1:3	m2	14.53	128.38	1865.16
4.5	back fill	m3	0.54	257.60	137.96
				SUM	**17880.72**
5	**Drop Structure**				
5.1	V.Excavation	m3	431.37	229.81	99132.04
5.2	V.massonary cement to sand ratio 1:3	m3	1238.03	1073.96	1329594.08
5.3	Plastering work cement tosand ratio 1:3	m2	531.74	128.38	68264.25
5.4	V.back fill	m3	102.56	257.60	26420.23
				SUM	**1523410.60**
6	**Crossing Structure**				
6.1	Foundation Excavation work	m3	15.00	229.81	3447.15
6.2	Concrete work (Price includes the cost of labor ,equipment ,supply of materials as well as mixing ,placing and curing plus formwork)				
6.2.1	10cm thick lean concrete under the footing pad 1:3:6 mix ratio	m3	4.00	2037.00	8148.00
6.2.2	RCC Concrete C-25 in footing pad columns	m3	5.00	2531.71	12658.55
6.2.3	RCC concrete for columns C-25	m3	55.00	2531.71	139244.05
6.2.4	flume RCC (C-25)	m3	60.00	2531.71	151902.60
6.2.5	Reinforcement bar (Supply, cut, bend, and tie in position reinforcement bars as per the drawing & bar schedule shown)				
6.2.5.1	Φ6mm	Kg	217.56	50.00	10878.00
6.2.5.2	Φ10mm	Kg	376.37	50.00	18818.50
6.2.5.	Φ16mm	Kg	6134.42	50.00	306720.75

	Total Quantity For Msrar teli infrastructure				
1	**Main Canal**	**Unit**	**Total Volume**	**unit rate**	**Total Birr**
3					
				SUM	**651817.60**
7	Foot Path				
7.1	V.Excavation	m3	28.53	229.81	6555.69
7.2	massonary work cement to sand ratio 1:3	m3	10.94	1073.96	11747.94
7.3	Concrete(C-15(	m3	3.00	2009.59	6028.77
7.4	Plastering work cement tosand ratio 1:3	m2	34.54	128.38	4433.81
7.5	V.back fill	m3	14.32	257.60	3688.91
				SUM	**32455.12**
8	Road crossing				
8.1	V.Excavation	m3	10.00	229.81	2298.10
8.2	massonary work cement to sand ratio 1:3	m3	2.00	1073.96	2147.92
8.3	Manufacture & installation of reinforced concrete pipes, 40cm in diameter and 4mlong each(1m length is available in market)	no	4.00	2000.00	8000.00
8.4	Plastering work cement tosand ratio 1:3	m2	0.00	128.38	0.00
8.5	V.back fill	m3	0.00	257.60	0.00
			SUM		**12446.02**
			Total cost of infrastracture		**9636678.38**

Annex

River cross section and rating curve

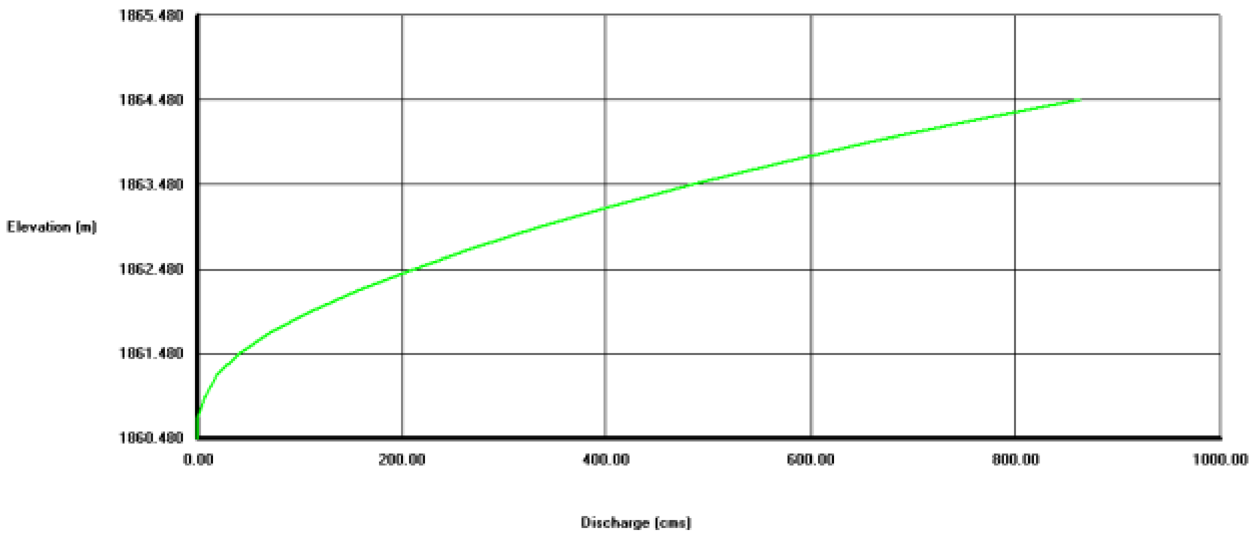


River rating Curve

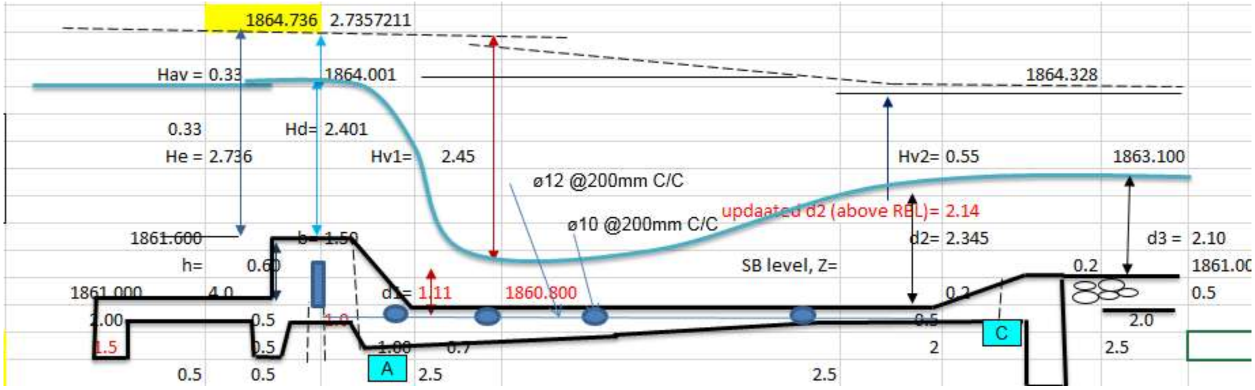
Rating CurveTable

Rating Curve Table for User Defined Channel

Total		Right			Main			Left		
(Q (cms	(Q (cms	(V (m/s	(A (sq.m	(Q (cms	(V (m/s	(A (sq.m	(Q (cms	(V (m/s	(A (sq.m	(Elev. (m
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1860.480
1.130	0.000	0.000	0.000	1.130	1.135	0.995	0.000	0.000	0.000	1860.730
7.158	0.000	0.000	0.000	7.158	1.912	3.744	0.000	0.000	0.000	1860.980
19.598	0.000	0.000	0.000	19.598	2.513	7.798	0.000	0.000	0.000	1861.230
41.067	0.000	0.000	0.000	41.067	3.193	12.862	0.000	0.000	0.000	1861.480
71.227	0.000	0.000	0.000	71.227	3.829	18.604	0.000	0.000	0.000	1861.730
111.084	0.000	0.000	0.000	111.084	4.509	24.636	0.000	0.000	0.000	1861.980
157.926	0.000	0.000	0.000	157.926	5.120	30.845	0.000	0.000	0.000	1862.230
211.400	0.000	0.000	0.000	211.400	5.678	37.233	0.000	0.000	0.000	1862.480
271.262	0.000	0.000	0.000	271.262	6.193	43.799	0.000	0.000	0.000	1862.730
336.453	0.000	0.000	0.000	336.453	6.655	50.558	0.000	0.000	0.000	1862.980
407.623	0.000	0.000	0.000	407.623	7.084	57.541	0.000	0.000	0.000	1863.230
484.987	0.000	0.000	0.000	484.987	7.490	64.750	0.000	0.000	0.000	1863.480
568.550	0.000	0.000	0.000	568.550	7.876	72.184	0.000	0.000	0.000	1863.730
658.333	0.000	0.000	0.000	658.333	8.245	79.844	0.000	0.000	0.000	1863.980
755.590	0.000	0.000	0.000	755.590	8.613	87.725	0.000	0.000	0.000	1864.230
863.553	0.000	0.000	0.000	863.553	9.021	95.727	0.000	0.000	0.000	1864.480


1865.480
1864.480
1863.480
Elevation (m)
1862.480
1861.480
1860.480
0.00
200.00
400.00
600.00
800.00
1000.00
Discharge (cms)

Head work design



Under Sluice Design

Allowed %tage of design flood, Qsluice=		2				
Thus, discharge through sluices, Qsluice=		4.368154				
Number of sluices proposed =		3	Thus Q per each sluice, Qsluice			1.456051
L= bc =Qd/(C*H3/2), Where H = h+Hd (for the case of design flood)=				0.164724	say	1
Thus, unit discharge, q in sluice channel=			1.456051			
Now, critical depth, dc =(q^2/g)^(1/3)=			0.600106			
h = head above center of opening orifice			2.701282			
Thus, critical velocity, Vc = q/dc =			2.426323			
Velocity through each, Vsluice =			7.280052			
Check if Vsluice > Vc	Ok!					

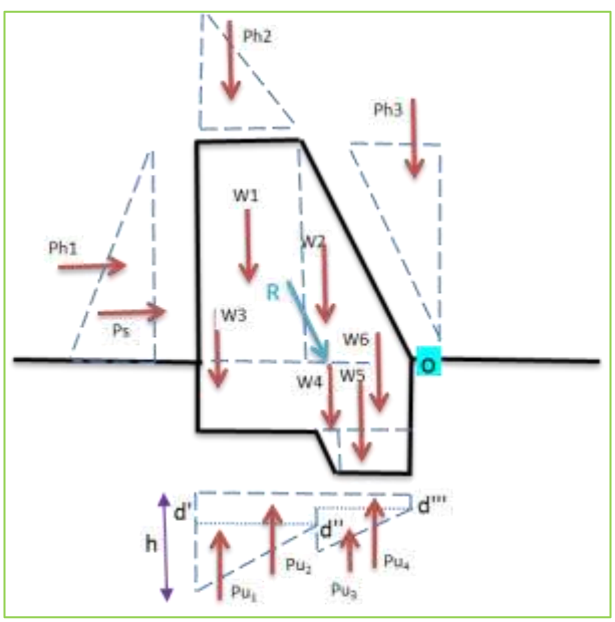
Allowed %tage of design flood, Q_{sluice}=		10				
Thus, discharge through sluices, Q_{sluice}=		22.00m3/s				
Number of sluices proposed =		15.11177	Thus Q per each sluice, Q_{sluice}=			1.46m3/s
$L= b_c = Q_d/(C*H^{3/2})$, Where H = h+Hd (for the case of design flood)=				0.16m	say	1.0m
Thus, unit discharge, q in sluice channel=			1.46m3/s/m			
Now, critical depth, dc =(q^2/g)^(1/3)=			0.6m			
h = head above center of opening orifice			2.70m			
Thus, critical velocity, Vc = q/dc =			2.426m/s			
Velocity through each, V_{sluice} =			7.28m/s			
Check if V_{sluice} > Vc	Ok!					

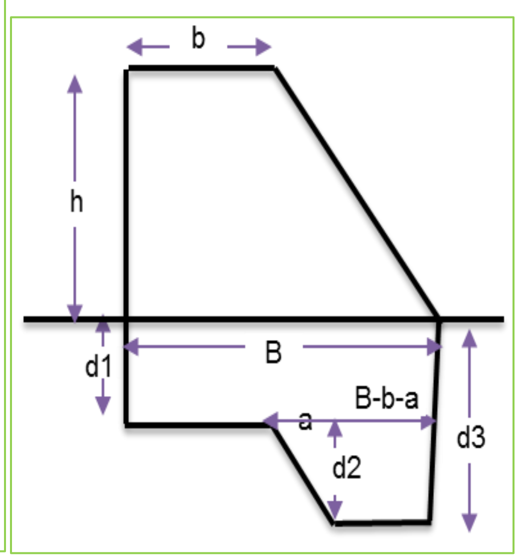
Stability analysis for high flood condition						
Name of forces	**Sym bol**	**Forces (KN)**		**Lever arm**	**Moments (KN-m)**	
		Vertical (+)	Horizont al (-)		(+)	(-)
1.Vertical forces						
1.1 down ward						
Weight of weir	W1	20.7		1.8	36.2	
	W2	6.9		0.7	4.6	
	W3	5.8		2.3	13.4	
	W4	13.7		1.0	13.7	
	W5	11.5		0.7	7.7	
	W6	24.0		0.5	12.0	
Subtotal		82.5	0		87.6	0
weight of water	Ph2	18.0		1.0	18.0	
	Ph3	3.0		0.2	0.6	
Subtotal	ΣWw	21.0	0		18.6	0
Subtotal of (1)		103.5	0		106.2	0
1.2 Upward forces						
uplift	Pu1		12.5	1.7		20.83
	Pu2		12.5	1.3		15.63
Subtotal	Σpu	0.0	25		0.0	36.46
Summation ΣV & ΣM		186.1	25		193.8	36.46
2. Horizontal force						
2.1 u/s water pressure						
	P1		1.8	0.2		0.36
2.2 u/s silt pressure						
	Ps		1.9	0.2		0.39
Summation ΣH & ΣM		0.0	3.7		0	0.75
Total		186.1	28.7		193.7967	37.21
1. Sliding						
		4.2	ok!	Resultant force R =		188.29

2. Over-turning				Max. Allowable BC of fine sand.KN/m2		
		5.2	ok!	Min. Allowable BC of fine sand.KN/m2		
3. Vertical stress/Tension			B or L=	2.5	B/6 =	0.42
		åM=åM+ - åM-		156.588469		
		Arm of Resultant force from toe, X i.e. centroidal distance=åM/åFv=				
		Eccentricity, e =	0.41	ok!		
4. Contact Pressure, Pmax/min						
		Pmax =	147.40	ok!	at the downstream face	
		Pmin =	1.46	ok!	i.e. for pond level case, at the upstream face	
Stability analysis for no over flow condition						

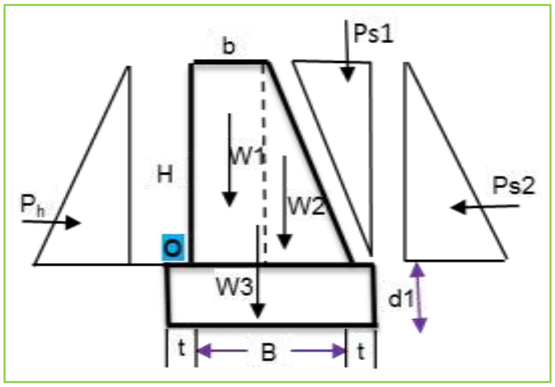
Name of forces	Symbol	Forces (KN)		Lever arm	Moments (KN-m)	
		Vertical (+)	Horizontal (-)		(+)	(-)
1.Vertical forces						
1.1 down ward forces						
Weight of weir	W1	20.7		1.8	36.2	
	W2	6.9		0.7	4.6	
	W3	5.8		2.3	13.4	
	W4	13.7		1.0	13.7	
	W5	12.0		0.7	8.0	
	W6	24.0		0.5	12.0	
Subtotal of (1)		83.0	0		87.9	0.0
1.2 Upward forces						
uplift	Pu1		12.5	1.7		20.8
	Pu2		12.5	1.3		15.6
Subtotal	Σpu	0.0	25		0.0	36.5
Summation ΣV & ΣM		83.0	25		87.9	36.5
2. Horizontal force						
2.1 u/s water pressure						
	P1		1.8	0.2		0.4
2.2 u/s silt pressure						
	Ps		1.95	0.2		0.4
Summation ΣH & ΣM		0.0	3.75		0	0.7
Total		83.0	28.75		87.9	37.2
1. Sliding						
		1.9	ok!	Resultant force R =		87.9
2. Over-turning				Max. Allowable BC of fine sand.KN/m2		
		2.4	ok!	Min. Allowable BC of fine sand.KN		

				/m3		
3. Tension			B or L=	2.5	B/6 =	0.42
		åM=åM+ - åM-		50.7184533		
		Arm of Resultant force from toe, X i.e. centroidal distance=åM /åFv=				
		Eccentricity, e =	0.64	ok		
4. Vertical stress Pmax/min						
		Pmax =	84.17	Ok!		
		Pmin =	-17.74	Ok!		





Forces acting on a Critical Section of a Weir



Forces acting on a wing wall

Stability Analysis of Retaining Walls						
Name of forces	Symbol	Forces (KN)		Lever arm	Moments (KN-m)	
		Vertical (+)	Horizontal (-)		(+)	(-)
Weight of Retaining Walls	W1	42.96		0.3	10.7	
	W2	85.92		1.2	100.2	
	W3	46.00		1.3	57.5	
Soil self-weight	Ps1	76.06		1.8	139.4	
Active soil pressure	Ps2		76.06	1.2		94.7

Stability Analysis of Retaining Walls						
Water Pressure	Ph1	55.64		1.1	61.9	
Total		306.6	76.06		369.8	94.7
1. Sliding						
		2.6	Ok!	Resultant force R =		315.9
2. Over-turning				Allowable compressive stress in masonry kg/cm2 =		
		3.904361	Ok!	Allowable tensile stress in masonry kg/cm2=		
3. Tension			B or L=	2.5	B/6 =	0.417
		åM=åM+ - åM-		275.07		

Stability Analysis of Retaining Walls						
		Arm of Resultant force from toe, X i.e. centroidal distance=åM/åFv =				
		Eccentricity, e =	0.352758	ok!		
4. Vertical stress Pmax/min						
		Pmax =	226.451	ok!		
		Pmin =	18.80912	ok!		

Structural design of under sluice gate

Head regulators structural design						
U/S water pressure P_{h1} =			448.69	N		
Bending moment			20.19	kgm =	2,019.09	kgcm
Thickness of the steel plate	$t=\sqrt{\frac{6\times M}{\sigma_t\times b}}=\sqrt{\frac{6\times 201909}{1500\times 100}}=$		0.28	cm		
			3	mm		
			0.015			
Weight of steel plat gate			-	kg		
Weight of spindle			4.85	kg		
Total weight		4.85	kg			
Shutting (buckling) force =				179.47	kg	
Moment of inertia	$I=\frac{L^2\times N_d\times Fs}{\pi^2\times E}=$			5.25	cm^4	
Inside diameter (d)	$d=\sqrt[4]{\frac{64\times I}{\pi}}=$			3.22	cm	
Outside diameter D = d + P/2(pitch height)				3.85	cm	
			say	40.0	mm	
Tensile force F_t=			184.33	kg		
Let d = 40-6.35 =			33.65	cm		
			3.37	mm		
Tensile stress	$\sigma_t=\frac{4\times F_t}{\pi\times d^2}=$			20.74	kg/cm2	
				Ckeck	ok!	

Structural design for head regulator

Head regulators structural design					
U/S water pressure P_{h1} =		448.69	kg		
Bending moment		20.19	kgm =	2,019.09	kgcm
Thickness of the steel plate		0.28	cm		
		3	mm		
		0.015			
Weight of steel plat gate		-	kg		
Weight of spindle		5.27	kg		
Total weight	5.27	kg			
Shutting (buckling) force =			179.47	kg	
Moment of inertia	$I = \frac{L^2 \times N_d \times Fs}{\pi^2 \times E} =$		6.19	cm^4	
Inside diameter (d)	$d = \sqrt{\frac{64 \times I}{\pi}} =$		3.35	cm	
Outside diameter D = d + P/2(pitch height)			3.99	cm	
		say	40.0	mm	
Tensile force F_t=		184.74	kg		
Let d = 40-6.35 =		33.65	cm		
		3.37	mm		
Tensile stress	$\sigma_t = \frac{4 \times F_t}{\pi \times d^2} =$		20.78	kg/cm2	
			Ckeck	ok!	
Structural design of operating deck					

Main canal

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
0.00	1861.20	0.4	0.00	0.4	0.0025	0.20		1861.20	1861.58	1861.78
42.83	1860.76	0.4	0.00	0.4	0.0025	0.20		1861.09	1861.47	1861.67
48.24	1861.05	0.4	0.00	0.4	0.0025	0.20		1861.08	1861.46	1861.66
53.84	1861.42	0.4	0.00	0.4	0.0025	0.20		1861.06	1861.44	1861.64
62.28	1861.99	0.4	0.00	0.4	0.0025	0.20		1861.04	1861.42	1861.62
74.22	1861.85	0.4	0.00	0.4	0.0025	0.20		1861.01	1861.39	1861.59
87.29	1861.86	0.4	0.00	0.4	0.0025	0.20		1860.98	1861.36	1861.56
98.73	1862.18	0.4	0.00	0.4	0.0025	0.20		1860.95	1861.33	1861.53
111.79	1862.33	0.4	0.00	0.4	0.0025	0.20		1860.92	1861.30	1861.50
230.66	1861.20	0.4	0.00	0.4	0.0025	0.20		1860.62	1861.00	1861.20
235.30	1860.64	0.4	0.00	0.4	0.0025	0.20		1860.61	1860.99	1861.19

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
244.48	1860.13	0.4	0.00	0.4	0.0025	0.20		1860.59	1860.96	1861.16
257.64	1860.90	0.4	0.00	0.4	0.0025	0.20		1860.55	1860.93	1861.13
272.81	1860.81	0.4	0.00	0.4	0.0025	0.20		1860.51	1860.89	1861.09
289.36	1860.81	0.4	0.00	0.4	0.0025	0.20		1860.47	1860.85	1861.05
298.78	1860.83	0.4	0.00	0.4	0.0025	0.20		1860.45	1860.83	1861.03
306.32	1860.53	0.4	0.00	0.4	0.0025	0.20		1860.43	1860.81	1861.01
313.32	1860.59	0.4	0.00	0.4	0.0025	0.20		1860.41	1860.79	1860.99
314.62	1860.93	0.4	0.00	0.4	0.0025	0.20		1860.41	1860.79	1860.99
322.29	1860.81	0.4	0.00	0.4	0.0025	0.20		1860.39	1860.77	1860.97
329.40	1860.58	0.4	0.00	0.4	0.0025	0.20		1860.37	1860.75	1860.95
338.16	1860.28	0.4	0.00	0.4	0.0025	0.20		1860.35	1860.73	1860.93
346.22	1860.14	0.4	0.00	0.4	0.0025	0.20		1860.33	1860.71	1860.91
351.77	1859.97	0.4	0.00	0.4	0.0025	0.20		1860.32	1860.69	1860.89
360.43	1860.29	0.4	0.00	0.4	0.0025	0.20		1860.29	1860.67	1860.87
367.74	1860.84	0.4	0.00	0.4	0.0025	0.20		1860.28	1860.65	1860.85
376.87	1860.33	0.4	0.00	0.4	0.0025	0.20		1860.25	1860.63	1860.83
383.62	1860.21	0.4	0.00	0.4	0.0025	0.20		1860.24	1860.61	1860.81
392.82	1860.14	0.4	0.00	0.4	0.0025	0.20		1860.21	1860.59	1860.79
400.84	1860.97	0.4	0.00	0.4	0.0025	0.20		1860.19	1860.57	1860.77
408.03	1862.21	0.4	0.00	0.4	0.0025	0.20		1860.17	1860.55	1860.75
416.57	1862.20	0.4	0.00	0.4	0.0025	0.20		1860.15	1860.53	1860.73
425.90	1861.47	0.4	0.00	0.4	0.0025	0.20		1860.13	1860.51	1860.71
436.09	1862.02	0.4	0.00	0.4	0.0025	0.20		1860.10	1860.48	1860.68
445.16	1861.41	0.4	0.00	0.4	0.0025	0.20	1.50	1860.08	1860.46	1860.66
466.66	1858.43	0.4	0.00	0.4	0.0025	0.20		1858.53	1858.90	1859.10
469.95	1858.53	0.4	0.00	0.4	0.0025	0.20		1858.52	1858.90	1859.10

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
477.53	1858.20	0.4	0.00	0.4	0.0025	0.20		1858.50	1858.88	1859.08
538.20	1857.79	0.4	0.00	0.4	0.0025	0.20	1.50	1858.35	1858.73	1858.93
546.29	1857.61	0.4	0.00	0.4	0.0025	0.20		1856.83	1857.20	1857.40
551.26	1857.46	0.4	0.00	0.4	0.0025	0.20		1856.81	1857.19	1857.39
558.28	1857.02	0.4	0.00	0.4	0.0025	0.20	1.50	1856.80	1857.17	1857.37
566.60	1855.81	0.4	0.00	0.4	0.0025	0.20		1855.28	1855.65	1855.85
573.83	1854.75	0.4	0.00	0.4	0.0025	0.20		1855.26	1855.64	1855.84
581.18	1854.09	0.4	0.00	0.4	0.0025	0.20		1854.09	1854.47	1854.67
588.74	1853.63	0.4	0.00	0.4	0.0025	0.20		1854.07	1854.45	1854.65
615.10	1850.52	0.4	0.00	0.4	0.0025	0.20	1.50	1850.52	1850.90	1851.10
643.13	1848.28	0.4	0.00	0.4	0.0025	0.20		1848.95	1849.33	1849.53
652.85	1847.68	0.4	0.00	0.4	0.0025	0.20		1848.92	1849.30	1849.50
689.37	1851.49	0.4	0.00	0.4	0.0025	0.20		1848.83	1849.21	1849.41
705.02	1849.67	0.4	0.00	0.4	0.0025	0.20	1.50	1848.79	1849.17	1849.37
717.13	1847.01	0.4	0.00	0.4	0.0025	0.20		1847.26	1847.64	1847.84
729.36	1848.26	0.4	0.00	0.4	0.0025	0.20		1847.23	1847.61	1847.81
737.68	1847.57	0.4	0.00	0.4	0.0025	0.20		1847.21	1847.59	1847.79
746.53	1847.29	0.4	0.00	0.4	0.0025	0.20		1847.19	1847.57	1847.77
766.90	1850.56	0.4	0.00	0.4	0.0025	0.20		1847.14	1847.52	1847.72
781.38	1847.12	0.4	0.00	0.4	0.0025	0.20	0.50	1847.10	1847.48	1847.68
802.31	1846.76	0.4	0.00	0.4	0.0025	0.20		1846.55	1846.93	1847.13
815.41	1846.72	0.4	0.00	0.4	0.0025	0.20		1846.52	1846.89	1847.09
837.99	1846.40	0.4	0.00	0.4	0.0025	0.20		1846.46	1846.84	1847.04
846.28	1846.08	0.4	0.00	0.4	0.0025	0.20		1846.44	1846.82	1847.02
852.58	1846.74	0.4	0.00	0.4	0.0025	0.20		1846.42	1846.80	1847.00
872.42	1846.46	0.4	0.00	0.4	0.0025	0.20		1846.37	1846.75	1846.95

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
888.08	1846.46	0.4	0.00	0.4	0.0025	0.20		1846.33	1846.71	1846.91
911.61	1842.34	0.4	0.00	0.4	0.0025	0.20		1846.27	1846.65	1846.85
932.53	1845.58	0.4	0.00	0.4	0.0025	0.20		1846.22	1846.60	1846.80
945.07	1845.71	0.4	0.00	0.4	0.0025	0.20		1846.19	1846.57	1846.77
966.92	1845.27	0.4	0.00	0.4	0.0025	0.20		1846.13	1846.51	1846.71
980.43	1845.59	0.4	0.00	0.4	0.0025	0.20		1846.10	1846.48	1846.68
1004.37	1845.99	0.4	0.00	0.4	0.0025	0.20		1846.04	1846.42	1846.62
1016.56	1846.36	0.4	0.00	0.4	0.0025	0.20	0.50	1846.01	1846.39	1846.59
1046.95	1845.14	0.4	0.00	0.4	0.0025	0.20		1845.43	1845.81	1846.01
1050.63	1845.34	0.4	0.00	0.4	0.0025	0.20		1845.42	1845.80	1846.00
1052.30	1845.51	0.4	0.00	0.4	0.0025	0.20		1845.42	1845.80	1846.00
1062.55	1848.45	0.4	0.00	0.4	0.0025	0.20		1845.39	1845.77	1845.97
1074.75	1844.95	0.4	0.00	0.4	0.0025	0.20		1845.36	1845.74	1845.94
1085.26	1841.56	0.4	0.00	0.4	0.0025	0.20		1845.34	1845.72	1845.92
1090.91	1843.88	0.4	0.00	0.4	0.0025	0.20		1845.32	1845.70	1845.90
1105.47	1845.65	0.4	0.00	0.4	0.0025	0.20		1845.29	1845.66	1845.86
1118.99	1845.03	0.4	0.00	0.4	0.0025	0.20		1845.25	1845.63	1845.83
1133.35	1844.03	0.4	0.00	0.4	0.0025	0.20		1845.22	1845.59	1845.79
1138.36	1843.30	0.4	0.00	0.4	0.0025	0.20		1845.20	1845.58	1845.78
1143.21	1845.38	0.4	0.00	0.4	0.0025	0.20		1845.19	1845.57	1845.77
1152.41	1844.93	0.4	0.00	0.4	0.0025	0.20		1845.17	1845.55	1845.75
1168.42	1845.26	0.4	0.00	0.4	0.0025	0.20		1845.13	1845.51	1845.71
1186.01	1844.39	0.4	0.00	0.4	0.0025	0.20		1845.08	1845.46	1845.66
1196.27	1845.05	0.4	0.00	0.4	0.0025	0.20		1845.06	1845.44	1845.64
1209.55	1845.24	0.4	0.00	0.4	0.0025	0.20		1845.02	1845.40	1845.60
1217.76	1844.08	0.4	0.00	0.4	0.0025	0.20		1845.00	1845.38	1845.58

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
1229.78	1843.39	0.4	0.00	0.4	0.0025	0.20		1844.97	1845.35	1845.55
1236.33	1843.75	0.4	0.00	0.4	0.0025	0.20		1844.96	1845.34	1845.54
1243.73	1844.99	0.4	0.00	0.4	0.0025	0.20		1844.94	1845.32	1845.52
1270.28	1845.81	0.4	0.00	0.4	0.0025	0.20		1844.87	1845.25	1845.45
1295.08	1844.73	0.4	0.00	0.4	0.0025	0.20		1844.81	1845.19	1845.39
1313.18	1844.54	0.4	0.00	0.4	0.0025	0.20		1844.76	1845.14	1845.34
1321.44	1845.51	0.4	0.00	0.4	0.0025	0.20		1844.74	1845.12	1845.32
1330.19	1846.23	0.4	0.00	0.4	0.0025	0.20		1844.72	1845.10	1845.30
1336.19	1849.07	0.4	0.00	0.4	0.0025	0.20		1844.71	1845.08	1845.28
1357.29	1844.33	0.4	0.00	0.4	0.0025	0.20		1844.65	1845.03	1845.23
1395.53	1844.93	0.4	0.00	0.4	0.0025	0.20		1844.56	1844.94	1845.14
1427.72	1844.32	0.4	0.00	0.4	0.0025	0.20		1844.48	1844.85	1845.05
1461.27	1844.66	0.4	0.00	0.4	0.0025	0.20		1844.39	1844.77	1844.97
1498.42	1844.09	0.4	0.00	0.4	0.0025	0.20		1844.30	1844.68	1844.88
1541.84	1844.65	0.4	0.00	0.4	0.0025	0.20		1844.19	1844.57	1844.77
1581.64	1844.68	0.4	0.00	0.4	0.0025	0.20		1844.09	1844.47	1844.67
1611.08	1843.98	0.4	0.00	0.4	0.0025	0.20		1844.02	1844.39	1844.59
1641.21	1844.49	0.4	0.00	0.4	0.0025	0.20		1843.94	1844.32	1844.52
1655.81	1844.13	0.4	0.00	0.4	0.0025	0.20		1843.90	1844.28	1844.48
1687.22	1843.95	0.4	0.00	0.4	0.0025	0.20		1843.82	1844.20	1844.40
1712.86	1843.86	0.4	0.00	0.4	0.0025	0.20		1843.76	1844.14	1844.34
1736.74	1843.61	0.4	0.00	0.4	0.0025	0.20		1843.70	1844.08	1844.28
1785.22	1843.76	0.4	0.00	0.4	0.0025	0.20		1843.58	1843.96	1844.16
1803.19	1844.58	0.4	0.00	0.4	0.0025	0.20		1843.53	1843.91	1844.11
1822.73	1844.56	0.4	0.00	0.4	0.0025	0.20		1843.48	1843.86	1844.06
1837.54	1844.28	0.4	0.00	0.4	0.0025	0.20		1843.45	1843.82	1844.02

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
1857.70	1843.85	0.4	0.00	0.4	0.0025	0.20		1843.40	1843.77	1843.97
1867.27	1843.71	0.4	0.00	0.4	0.0025	0.20		1843.37	1843.75	1843.95
1889.16	1843.66	0.4	0.00	0.4	0.0025	0.20		1843.32	1843.69	1843.89
1903.65	1844.75	0.2	0.00	0.2	0.0025	0.20		1843.28	1843.50	1843.70
1918.14	1842.17	0.2	0.00	0.2	0.0413	0.20	1.50	1842.91	1843.14	1843.34
1940.50	1842.08	0.2	0.00	0.2	0.0413	0.20		1840.49	1840.71	1840.91
1945.19	1841.20	0.2	0.00	0.2	0.0413	0.20	1.50	1840.29	1840.52	1840.72
1950.00	1838.43	0.2	0.00	0.2	0.0413	0.20	0.50	1838.60	1838.82	1839.02
2000.00	1835.78	0.2	0.00	0.2	0.0413	0.20	1.50	1836.03	1836.25	1836.45
2050.00	1832.11	0.2	0.00	0.2	0.0413	0.20		1832.46	1832.69	1832.89
2100.00	1829.82	0.2	0.00	0.2	0.0413	0.20		1830.40	1830.62	1830.82
2150.00	1830.59	0.2	0.00	0.2	0.0413	0.20		1828.33	1828.56	1828.76
2200.00	1829.83	0.2	0.00	0.2	0.0413	0.20		1826.27	1826.49	1826.69
2250.00	1824.32	0.2	0.00	0.2	0.0413	0.20		1824.20	1824.42	1824.62
2300.00	1821.91	0.4	0.00	0.4	0.0025	0.20		1822.14	1822.51	1822.71
2350.00	1822.11	0.4	0.00	0.4	0.0025	0.20		1822.01	1822.39	1822.59
2400.00	1822.14	0.4	0.00	0.4	0.0025	0.20		1821.88	1822.26	1822.46
2450.00	1822.25	0.4	0.00	0.4	0.0025	0.20		1821.76	1822.14	1822.34
2500.00	1820.85	0.4	0.00	0.4	0.0025	0.20		1821.63	1822.01	1822.21
2550.00	1821.96	0.4	0.00	0.4	0.0025	0.20		1821.51	1821.88	1822.08
2600.00	1821.96	0.4	0.00	0.4	0.0025	0.20		1821.38	1821.76	1821.96
2650.00	1822.00	0.4	0.00	0.4	0.0025	0.20		1821.26	1821.63	1821.83
2700.00	1821.80	0.4	0.00	0.4	0.0025	0.20		1821.13	1821.51	1821.71
2750.00	1822.49	0.4	0.00	0.4	0.0025	0.20		1821.00	1821.38	1821.58

Secondary canal-1

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
0	1821.56	0.3	0.0	0.13	0.0388	0.20		1821.56	1821.69	1821.89
20	1820.90	0.3	0.0	0.13	0.0388	0.20		1820.78	1820.91	1821.11
40	1820.23	0.3	0.0	0.13	0.0388	0.20		1820.01	1820.14	1820.34
60	1819.75	0.3	0.0	0.13	0.0388	0.20		1819.23	1819.36	1819.56
80	1819.84	0.3	0.0	0.13	0.0388	0.20		1818.46	1818.59	1818.79
100	1819.15	0.3	0.0	0.13	0.0388	0.20		1817.68	1817.81	1818.01
120	1818.15	0.3	0.0	0.13	0.0388	0.20		1816.91	1817.04	1817.24
140	1816.22	0.3	0.0	0.13	0.0388	0.20		1816.13	1816.26	1816.46
160	1815.48	0.3	0.0	0.13	0.0388	0.20		1815.36	1815.49	1815.69
180	1814.85	0.3	0.0	0.13	0.0388	0.20	1.50	1814.59	1814.72	1814.92
200	1812.48	0.3	0.0	0.13	0.0388	0.20		1812.31	1812.44	1812.64
219	1810.78	0.3	0.0	0.13	0.0388	0.20	1.50	1811.54	1811.67	1811.87
239	1808.98	0.3	0.0	0.13	0.0388	0.20		1809.27	1809.40	1809.60
259	1808.12	0.3	0.0	0.13	0.0388	0.20		1808.49	1808.62	1808.82
279	1806.93	0.3	0.0	0.13	0.0388	0.20		1807.71	1807.84	1808.04
299	1806.76	0.3	0.0	0.13	0.0388	0.20		1806.96	1807.09	1807.29
319	1807.04	0.3	0.0	0.13	0.0388	0.20		1806.18	1806.31	1806.51
339	1806.96	0.3	0.0	0.13	0.0388	0.20		1805.40	1805.53	1805.73
359	1805.42	0.3	0.0	0.13	0.0388	0.20		1804.63	1804.76	1804.96
379	1803.87	0.3	0.0	0.13	0.0388	0.20		1803.86	1803.99	1804.19
399	1802.38	0.3	0.0	0.13	0.0388	0.20	1.50	1803.08	1803.21	1803.41
419	1801.05	0.3	0.0	0.13	0.0388	0.20		1800.81	1800.94	1801.14
439	1799.71	0.3	0.0	0.13	0.0388	0.20		1800.03	1800.16	1800.36
459	1798.35	0.3	0.0	0.13	0.0388	0.20	1.50	1799.25	1799.38	1799.58
478	1797.21	0.3	0.0	0.13	0.0388	0.20		1796.99	1797.12	1797.32

Secondary canal-2

Chainage (m)	**OGL (m)**	**b (m)**	**m**	**d (m)**	**S (m/m)**	**FB (m)**	**Drop (m)**	**CBL (m)**	**FSL (m)**	Canal bank level (m)
0.00	1816.99	0.30	0.00	0.15	0.0445	0.20	1.50	1816.99	1817.14	1817.34
20.00	1815.31	0.30	0.00	0.15	0.0445	0.20		1814.60	1814.75	1814.95
40.00	1813.79	0.30	0.00	0.15	0.0445	0.20		1813.71	1813.86	1814.06
60.00	1813.10	0.30	0.00	0.15	0.0445	0.20		1812.82	1812.96	1813.16
79.98	1812.26	0.30	0.00	0.15	0.0445	0.20	1.50	1811.93	1812.07	1812.27
99.67	1810.66	0.30	0.00	0.15	0.0445	0.20		1809.55	1809.70	1809.90
119.67	1808.36	0.30	0.00	0.15	0.0445	0.20		1808.66	1808.81	1809.01
139.54	1807.25	0.30	0.00	0.15	0.0445	0.20	1.50	1807.78	1807.92	1808.12
158.00	1806.31	0.30	0.00	0.15	0.0445	0.20		1805.45	1805.60	1805.80
178.00	1805.49	0.30	0.00	0.15	0.0445	0.20		1804.56	1804.71	1804.91
197.69	1804.29	0.30	0.00	0.15	0.0445	0.20	1.50	1803.69	1803.83	1804.03
217.69	1802.05	0.30	0.00	0.15	0.0445	0.20		1801.29	1801.44	1801.64
237.05	1800.19	0.30	0.00	0.15	0.0445	0.20		1800.43	1800.58	1800.78
257.05	1799.40	0.30	0.00	0.15	0.0445	0.20		1799.54	1799.69	1799.89
277.02	1798.72	0.30	0.00	0.15	0.0445	0.20		1798.65	1798.80	1799.00
297.02	1798.28	0.30	0.00	0.15	0.0445	0.20		1797.76	1797.91	1798.11
315.51	1797.32	0.30	0.00	0.15	0.0445	0.20		1796.94	1797.09	1797.29
335.52	1796.24	0.30	0.00	0.15	0.0445	0.20		1796.05	1796.19	1796.39
355.21	1794.85	0.30	0.00	0.15	0.0445	0.20	1.50	1795.17	1795.32	1795.52
374.69	1793.66	0.30	0.00	0.15	0.0445	0.20		1792.80	1792.95	1793.15
394.63	1792.50	0.30	0.00	0.15	0.0445	0.20		1791.91	1792.06	1792.26
414.63	1791.52	0.30	0.00	0.15	0.0445	0.20		1791.02	1791.17	1791.37
434.63	1790.74	0.30	0.00	0.15	0.0445	0.20		1790.13	1790.28	1790.48
454.62	1790.24	0.30	0.00	0.15	0.0445	0.20		1789.24	1789.39	1789.59
474.62	1789.74	0.30	0.00	0.15	0.0445	0.20		1788.35	1788.50	1788.70
494.62	1788.21	0.30	0.00	0.15	0.0445	0.20		1787.46	1787.61	1787.81
514.60	1787.34	0.30	0.00	0.15	0.0445	0.20		1786.57	1786.72	1786.92

Secondary canal-3

Chainage (m)	OGL (m)	b (m)	m	d (m)	S (m/m)	FB (m)	Drop (m)	CBL (m)	FSL (m)	Canal bank level (m)
0.0	1814.86	0.30	0.00	0.15	0.0460	0.20		1814.86	1815.01	1815.21
20.0	1813.86	0.30	0.00	0.15	0.0460	0.20	1.50	1813.94	1814.09	1814.29
40.0	1812.58	0.30	0.00	0.15	0.0460	0.20		1811.52	1811.67	1811.87
60.0	1811.03	0.30	0.00	0.15	0.0460	0.20		1810.60	1810.75	1810.95
79.9	1809.93	0.30	0.00	0.15	0.0460	0.20		1809.68	1809.83	1810.03
99.9	1808.65	0.30	0.00	0.15	0.0460	0.20	1.50	1808.76	1808.91	1809.11
119.2	1806.64	0.30	0.00	0.15	0.0460	0.20	1.50	1806.38	1806.52	1806.72
138.1	1803.73	0.30	0.00	0.15	0.0460	0.20		1804.01	1804.16	1804.36
158.1	1803.95	0.30	0.00	0.15	0.0460	0.20		1803.09	1803.24	1803.44
177.5	1803.55	0.30	0.00	0.15	0.0460	0.20		1802.19	1802.34	1802.54
197.5	1802.23	0.30	0.00	0.15	0.0460	0.20		1801.27	1801.42	1801.62
216.8	1800.76	0.30	0.00	0.15	0.0460	0.20		1800.38	1800.53	1800.73
236.8	1799.96	0.30	0.00	0.15	0.0460	0.20		1799.46	1799.61	1799.81
256.8	1798.98	0.30	0.00	0.15	0.0460	0.20		1798.54	1798.69	1798.89
274.9	1798.21	0.30	0.00	0.15	0.0460	0.20		1797.71	1797.86	1798.06
294.9	1796.32	0.30	0.00	0.15	0.0460	0.20		1796.79	1796.94	1797.14
314.7	1797.31	0.30	0.00	0.15	0.0460	0.20		1795.88	1796.03	1796.23
334.7	1794.89	0.30	0.00	0.15	0.0460	0.20	1.50	1794.96	1795.11	1795.31
354.3	1793.29	0.30	0.00	0.15	0.0460	0.20		1792.56	1792.71	1792.91
374.3	1791.95	0.30	0.00	0.15	0.0460	0.20		1791.64	1791.79	1791.99
394.3	1791.21	0.30	0.00	0.15	0.0460	0.20		1790.72	1790.86	1791.06
414.1	1790.39	0.30	0.00	0.15	0.0460	0.20		1789.80	1789.95	1790.15
434.1	1789.66	0.30	0.00	0.15	0.0460	0.20		1788.88	1789.03	1789.23
454.1	1789.04	0.30	0.00	0.15	0.0460	0.20		1787.96	1788.11	1788.31
473.3	1788.58	0.30	0.00	0.15	0.0460	0.20		1787.08	1787.23	1787.43